(54) **DSL transmission system with far-end crosstalk cancellation**

(57) The invention relates to a far-end crosstalk (FEXT) canceling circuit for a digital subscriber line transmission system, said transmission system comprising a plurality of line termination modems receiving digital multitone symbols from corresponding network termination modems over a plurality of transmission channels. The invention proposes to estimate the modulated data Si(fj) actually transmitted by the NT modems from the frequency components (Ri) of the DMT symbols received by the LT modems i and to evaluate the FEXT as a linear combination of these estimates. FEXT cancellation for all the LT modems is also proposed in a centralized manner.
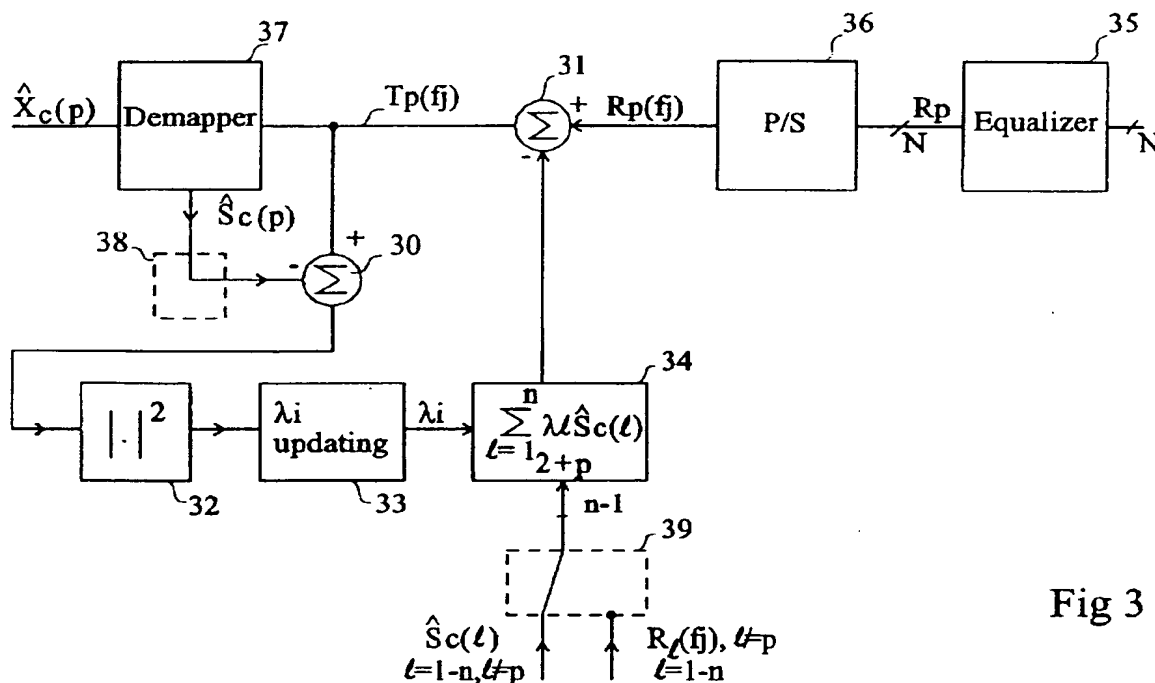
Fig 3

Description

FIELD OF THE INVENTION

[0001] The present invention relates to digital subscriber line transmission systems, which allow, in particular high speed communication on twisted pair telephone lines based on discrete multitone transmission (DMT). The invention relates more specifically to a far-end crosstalk (FEXT) canceller for canceling the crosstalk signal induced by modems located at the far-end of such a transmission system.

DISCUSSION OF THE RELATED ART

[0002] Figure 1 schematically shows a modem in a conventional DSL transmission system using digital multitone. The modem comprises a transmitter TX and a receiver RX. A serial stream of data X is provided to a mapper circuit 11 mapping each data into a symbol of a constellation, for example of a QAM (Quadrature Amplitude Modulation) constellation. The mapped values are then transformed into a set S of N components by a serial to parallel converter 12, each component of the set being considered as a frequency domain coefficient. This set of frequency domain coefficients, hereafter also called DMT symbol, is provided to an inverse fast Fourier transform (IFFT) circuit 13 which generates a time domain block of samples and is followed by a parallel/serial converter (P/S). This time domain block is therefore the sum of N sinusoidal subcarriers of different frequencies, the amplitude thereof being determined by the corresponding frequency domain coefficient received by the IFFT circuit.

[0003] Each time domain block is cyclically prefixed (cp) and suffixed (cs) in a block 19 to suppress or at least attenuate the Inter Symbol Interference (ISI) and the Inter Carrier Interference (ICI) caused by the channel, and is transmitted onto a telephone line 10 through a hybrid line interface 18. The line interface 18 also receives incoming time domain blocks from another modem connected to line 10.

[0004] At the receiving side, the incoming time domain blocks from line 10 are provided to a fast Fourier transform (FFT) circuit 14 through a block 19' that deletes the prefix and suffix and a serial/parallel converter (S/P) which calculates the N frequency domain coefficients for each block. The N frequency domain coefficients are then provided to an equalizer 15 which compensates for the attenuation and phase shift incurred by each frequency component. The equalized values are then serialized by a parallel to serial converter 16 into a stream of N complex numbers R(fj) and then processed by a demapper 17 attributing for each R(fj) the symbol $\hat{Sc}$ of the constellation which comes closest thereto. The demapper 17 further outputs the digital word $\hat{Xc}$ associated with the selected constellation point $\hat{Sc}$.

[0005] Figure 2 schematically shows a DSL transmission system comprising a central office 20 communicating with a plurality of end-users over telephone lines 25, 26. Modems 21, 22, 21', 22' have the structure represented in figure 1. The end of a telephone line connected to a modem of the central office 20 is called the line termination (LT) side while the end connected to a modem of an end-user is called the network termination (NT) side.

[0006] Ideally, such a DSL transmission system allows the whole frequency band to be used for simultaneous full-duplex transmissions. However, in practice, different sources of noise disturb the transmissions and impede proper reception of data.

[0007] For a given modem, three different sources of noise can be distinguished as illustrated in figure 2:

- the self-echo, i.e. for a given modem, the parasitic signal from the transmitter TX leaking to the receiver RX through the hybrid interface;
- the near-end crosstalk (NEXT) arising from signals in adjacent telephone lines 25, 26 with opposite transmission directions. More specifically, in the present example, the NEXT generated at the modem 21 is the parasitic signal received by this modem from the modem 22. In this instance the NEXT is called LT-NEXT because the modem 21 is located on the LT side. Reciprocally, the NEXT generated at modem 21' by the modem 22' is called NT-NEXT;
- the far-end crosstalk (FEXT) arises from signals traveling along the same transmission direction in adjacent telephone lines. More precisely, in the illustrated example, the FEXT generated at the modem 21 is the parasitic signal received by this modem from the modem 22' located on the opposite side, due to the coupling between the telephone lines 25 and 26 sharing a common binder. In this instance the FEXT is called LT-FEXT because the modem 21 is located on the LT side. Reciprocally, the FEXT generated at modem 21' by the modem 22 is called NT-FEXT.

[0008] Echo-cancellers for canceling self-echoes are known e.g. from unpublished European patent application N° 98410112 filed by the applicants. This document is however to be taken into account as prior art only under Art. 54(3) EPC.

[0009] There is also known from US-A-5887032 a canceller for canceling out the NEXT interference in an ADSL transmission system on the LT side. This canceller operates in the frequency domain and assumes, for a given subcarrier or tone, that the NEXT interference is proportional to the symbol value emitted by the modem transmitting on the interfering channel. The latter value is scaled by a given coefficient and subtracted from the symbol received by the modem suffering from the NEXT interference.

[0010] Both self-echo cancellation and LT-NEXT cancellation are possible because the signal transmitted by

the same modem (in the case of the self-echo) or by a neighboring modem of the central office (in the case of LT-NEXT interference) is directly available.

[0011] FEXT cancellation is however intrinsically more complex than NEXT or self-echo cancellation because the modem transmitting over the interfering channel is now located on the far-end side and the actual values of the interfering symbols are therefore not known.

SUMMARY OF THE INVENTION

[0012] An object of the present invention is to design a canceller circuit for a DMT based DSL transmission system capable of significantly removing the FEXT interference and having a simple structure.

[0013] Another object of the present invention is to design an efficient FEXT canceling method in a DMT based DSL transmission system.

[0014] These objects are attained by the invention as claimed.

[0015] The foregoing and other objects, features, aspects and advantages of the invention will become apparent from the following detailed description of embodiments, given by way of illustration and not of limitation with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

Figure 1, previously described, schematically shows the structure of a modem suitable for use in a DSL transmission system;

Figure 2, previously described, schematically shows the different types of noise occurring in a DSL transmission system;

Figure 3 shows a first and a second embodiment of a FEXT canceller according to the invention;

Figure 4 shows a third embodiment of a FEXT canceller according to the invention;

Figure 5 shows a fourth embodiment of a FEXT canceller according to the invention; and

Figure 6 schematically shows the overall structure of a DSL transmission system comprising a FEXT canceller according to the third or the fourth embodiment of the invention.

DESCRIPTION OF THE INVENTION

[0017] The invention is based on the idea that the actual value of a symbol causing FEXT interference at the LT side can be obtained from the modem receiving this symbol. The modem receiving the FEXT interfering symbol and the modem receiving the FEXT corrupted symbol being both located at the central office, a connection between the two modems can be realized.

[0018] Figure 3 shows a first embodiment of the in-

vention and more specifically a part of the receiver TX of a modem p on the LT side, receiving a FEXT corrupted signal. In this embodiment the blocks 38 and 39 represented with dotted lines do not exist.

[0019] Each modem i on the LT side is connected to a modem $c(i)$ on the NT side through a transmission channel. The blocks 35, 36, 37 correspond to the blocks 15, 16, 17 of the receiver RX illustrated in figure 1.

[0020] This first embodiment, aims at canceling the FEXT interference caused by the signals transmitted by n-1 modems $c(i)$, i=1 to n, i≠p.

[0021] For clarity purpose, we suppose first that a symbol carried by the subcarrier or tone fj is FEXT corrupted by symbols at the same frequency only. If we note, as illustrated on figure 2, $H(fj) = (H_{kl}(fj))$ the transfer matrix of the n transmission channels from the NT to the LT side, with $k,l = 1..,n$, fj being the frequency index with $j = 1..,n$, we can write in the frequency domain for the frequency fj:

$$R(fj) = H(fj) \cdot S(fj),$$

where $R(fj) = Rk(fj)$, $k = 1...n$, is the vector of the received frequency components and $S(fj) = Sk(fj)$, $k = 1...n$, is the vector of the transmitted DMT symbols from the n modems, for the frequency fj.

[0022] The FEXT interference for a given frequency fj and for a modem p can therefore be written:

$$FEXT(fj) = \sum_{l=1}^{n} Hlp(fj)Sl(fj), \quad l \neq p$$

[0023] According to the first embodiment of the invention, the complex values $\hat{S}l(fj)$, $l=1...n$, $l \neq p$ are approximated by the symbols $Sl(fj)$, i.e. by the symbols of the constellation coming the closest to the respective received frequency components $Rl(fj)$, $l=1...n$, $l \neq p$, respectively output by the demappers 37. This implies that the processing in the modem p is one-symbol delayed with respect to the other modems.

[0024] The complex symbols $\hat{S}l(fj)$ from the other modems, $l=1...n$, $l \neq p$, are then linearly combined in block 34 and subtracted by a subtractor 31 from the received frequency component $Rp(fj)$ to produce a FEXT-removed complex value $Tp(fj)$. The demapper 37 of modem p outputs a demapped word $\hat{X}p(fj)$ and the corresponding constellation point $\hat{S}p(fj)$. The complex value $\hat{S}p(fj)$ is subtracted from the complex value $Tp(fj)$ to produce an error value. This error value is squared in a circuit 32 and processed in a block 33 to update the coefficients of the linear combination, for example according to the known steepest gradient algorithm. The updated values stored in block 33 will be used for FEXT canceling the next frequency component $Rp(fj)$, i.e. the frequency component $Rp(fj)$ of the next incoming block. Af-

ter a few iterations, the linear combination coefficients converge towards the values Hlp(fj) of the transfer matrix.

[0025] We have considered above FEXT cancellation at a single tone fj. It is clear however that the processing should be repeated for all the tones j=1 to N, the frequency coefficients $Rp(fj)$ being sequentially output by the parallel to serial converter 36. The linear combination coefficients for each frequency fj are stored in the memory of block 33. After a few iterations the memory contains the values Hlp(fj), l=1...n and l≠p, j=1...N.

[0026] We have assumed above that the FEXT at the different frequencies could be independently canceled. In a conventional DMT transmission system this can only be regarded as an approximation since the limited duration of the time domain blocks causes a spreading of the frequency components. Generally, the FEXT at a frequency fj depends also upon frequency components transmitted at neighboring frequencies. This problem can be tackled in two different ways.

[0027] Firstly, the crosstalk canceller of figure 1 can be adapted so as to take into account intra-frequency crosstalk coefficients Hlp(fi,fj), the modification being straightforward: the linear combination coefficients are now function of a couple of frequencies fi, fj. The processing in modem p has also to be delayed for a full time block since the knowledge of the $\hat{S}l(fj)$ at all the frequencies is necessary before starting the FEXT cancellation.

[0028] Secondly, if the modems are synchronous Zipper modems as described in the international application WO97/06619, the assumption made above is fully valid, i.e. the FEXT at a frequency fj is independent from the frequency components transmitted at the frequencies fi, i≠j. Indeed, in such modems, the cyclic extension added to each time domain block before transmission eliminates any inter-frequency crosstalk.

[0029] Figure 4 shows a second embodiment of the invention. In this embodiment, the FEXT second interference is canceled in a centralized manner by a crosstalk canceller 40 operating now for all the LT modems or at least for all the LT modems cross-linked by the same FEXT. The crosstalk canceller 40 receives the sets of frequency components Ri, i=1 to n (Ri=Ri(fj), j=1 to N) from FFT circuits 44 and uses Ri to approximate $\hat{S}i(fj)$. At time t, the vector R constituted by the Ri's is multiplied by the matrix H^{-1}_{t-1} which is an estimate of the inverse of the transfer matrix at time t-1. The resulting vector is split up in n sets $(H^{-1}_{t-1}*R)_i$, each having N frequency components. Each set is parallel to serial converted by converters 46 and the frequency components $(H^{-1}_{t-1}*R)_i$ (fj) are then demapped by demappers 47. The demappers 47 output the nearest constellation symbols $\hat{S}i(fj)$ and the digital words $\hat{X}i(fj)$ associated therewith. For each line i, the N consecutive symbols $\hat{S}i$ (fj) belonging to the same time domain symbol are converted back by serial to parallel converters 48 and fed back to the crosstalk canceller circuit 40. The resulting

vector $\hat{S}_t$ of N*n components is built and the vector $H^{-1}_{t-1}*R$ is subtracted therefrom, giving an error vector of norm e_t. The coefficients of the matrix H^{-1}_{t-1} are then updated, for example according to the st epest gradient algorithm, to produce at time t+1 an updated matrix H^{-1}_t. The previous processing steps are iterated.

[0030] In contrast with the first and second embodiments, it should be emphasized that equalization is directly provided by the crosstalk canceller itself since it is taken into account by the diagonal coefficients of the matrix H^{-1}_t. In this embodiment the equalization coefficients and the crosstalk coefficients are co-estimated instead of being sequentially estimated. This leads to a more accurate evaluation of both groups of coefficients.

[0031] Figure 5 shows a fourth embodiment of the invention.

[0032] No assumption as to inter-frequency FEXT has been made with respect to the third embodiment. However, as discussed above, if the modems are of the synchronous Zipper type, the inter-frequency FEXT is negligible and the matrix H^{-1}_t has the simple form of a block matrix exhibiting blocks $H^{-1}_t(fj)$, j=1 to N along its diagonal. In such an instance, FEXT cancellation can be performed sequentially for each frequency in a more simple way, as illustrated by figure 5. In contrast with figure 4, parallel to serial converters 56 sequentially provide the frequency components Ri(fj) to the crosstalk canceller 50. The product of the vector R(fj) constituted by the Ri (fj)'s is multiplied by the matrix $H^{-1}_{t-1}(fj)$ which is an estimate of the inverse of the transfer matrix at time t-1 and frequency fj. The N components (complex scalar values) of the resulting vector are demapped by demappers 57 and the respective closest constellation symbols $\hat{S}i(fj)$, i=1 to N are fed back to the FEXT canceller. The error calculation and the updating of the coefficients are a simple transposition of those set out in the description of the third embodiment.

[0033] Figure 6 shows the overall structure of a DSL transmission system with a FEXT canceller 60 according to the third or the fourth embodiment connected to n LT modems M1... Mn. Each modem is connected to a bi-directional transmission line 61, an input Din and an output Dout for inputting the digital words X(i) to be transmitted and outputting the received words $\hat{X}i(fj)$. In addition, each modem has an input 63 for inputting the values $(H^{-1}*R)_i$ and an output 62 for outputting the nearest constellation symbols $\hat{S}i(fj)$.

[0034] Although the embodiments have been described with an adaptation of the linear combination coefficients / matrix coefficients for each time domain block received, it should be understood that this adaptation can be made at a much lower rate, depending upon the characteristics of the transmission channels.

Claims

1. A far-end crosstalk (FEXT) canceling circuit for a

digital subscriber line transmission system, said transmission system comprising a plurality (n) of line termination (LT) modems (Mi) receiving digital multitone (DMT) signals (ri) from corresponding network (NT) termination modems (Mi(fj)) over a plurality of transmission channels, each LT modem comprising time/frequency transforming means (FFT) for transforming said DMT signals into a DMT symbol Ri of frequency components Ri(fj) and demapping means outputting for each frequency component the symbol of the constellation nearest thereto ($\hat{S}i(fj)$) and the corresponding demodulated data ($\hat{X}i(fj)$), characterized in that it further comprises:

estimation means, in at least one LT modem, for estimating the constellation symbols Si(fj) actually sent by the modems (Mi(fj)), i≠p, from the frequency components (Ri) of the DMT symbols (Ri) received by all modems (Mi); calculation means (34, 31, 40) for calculating a linear combination of said estimated modulated data, for subtracting said linear combination from the frequency components Ri(fj) of said at least one modem and for applying the resulting difference to the demapping means of said at least one modem; error calculation means (30, 32, 40) for calculating the error distance between the constellation symbol ($\hat{S}p(fj)$) from said at least one modem and said difference; updating means for updating (33, 40) the coefficients of said linear combination as a function of said error distance.

2. The FEXT canceling circuit of claim 1, characterized in that the estimation means provides the constellation points ($\hat{S}i(fj)$) respectively output by the demappers of the modems i, i≠p as estimates for the modulated data $\hat{S}i(fj)$, i≠p.

3. The FEXT canceling circuit of claim 1, characterized in that the estimation means further comprises switching means (39) for outputting the frequency components (Ri(fj)) in a first step and the constellation symbols ($\hat{S}i(fj)$), i≠p, obtained therefrom in a second step as estimates for the modulated data (Si(fj)), i≠p.

4. The FEXT canceling circuit of claim 1, characterized in that:

the estimation means is common to all the LT modems and simultaneously provides the DMT symbols (Ri) as estimates for consecutive symbols ($\hat{S}i(fj)$); the calculating means is common to all the LT modems and comprises matrix calculation means calculating at time t the product $H^{-1}_{t-1}{}^{*}R$ of a matrix H^{-1}_{t-1} with the vector R, R being a vector constituted by all the sets of frequency components Ri, H^{-1}_{t-1} being an estimate at time t-1 of the inverse of the transfer matrix of the plurality of transmission channels; the error calculating means is common to all the LT modems and calculates the error distance between each of the n components of the vector $H^{-1}_{t}{}^{*}R$ and the constellation symbols ($\hat{S}i(fj)$) output by the respective demappers of the modems; the updating means is common to all the LT modems and updates the coefficients of the matrix H^{-1}_{t-1} as a function of said error distance.

5. The FEXT canceling circuit of claim 1, further comprising parallel to serial converters (56) transforming the DMT symbols Ri into respective serial streams of frequency components Ri(fj), wherein:

the estimation means (50) is common to all the LT modems and simultaneously provides the frequency components (Ri(fj)) as estimates for the symbols (Si(fj)); the calculating means (50) is common to all the LT modems and comprises matrix calculation means sequentially calculating at time t, for each tone j the product $H^{-1}_{t-1}(fj){}^{*}R(fj)$ of a matrix $H^{-1}_{t-1}(fj)$ with the vector R(fj) constituted by all the frequency components Ri(fj) at the frequency fj, $H^{-1}_{t-1}(fj)$ being an estimate at time t-1 of the inverse of the transfer matrix at the frequency fj of the plurality of transmission channels; the error calculating means is common to all the LT modems and sequentially calculates for each tone j the error distance between each of the n components of the vector $H^{-1}_{t}(fj){}^{*}R$ (fj) and the constellation points $\hat{S}i(fj)$ output by the respective demappers of the modems; the updating means is common to all the LT modems and sequentially updates for each tone j the coefficients of the matrix $H^{-1}_{t-1}(fj)$ as a function of said error distance.

6. A digital subscriber line transmission system comprising a crosstalk canceling circuit according to claim 4 or 5 in which the LT and NT modems are of the synchronous Zipper type.

7. A far-end crosstalk (FEXT) canceling method for a digital subscriber line transmission system, said transmission system comprising a plurality (n) of line termination (LT) modems (Mi) receiving digital multitone (DMT) signals (ri) from corresponding network (NT) termination modems (Mi(fj)) over a plurality of transmission channels, each LT modem comprising frequency transforming means (FFT) for

transforming said DMT signals into a DMT symbol (Ri) of frequency components $Ri(fj)$, and demapping means outputting for each frequency component the symbol of the constellation nearest thereto $(\hat{S}i(fj))$ and the corresponding demodulated data $(\hat{X}i(fj))$, characterized in that it comprises the following steps:

estimating, for at least one LT modem (p), the constellation symbols $(Si(fj))$ actually sent by all the modems $Mi(fj)$, $i{\neq}p$, from the frequency components of the DMT symbols (Ri) received by said modems;

calculating a linear combination of said estimated symbols, subtracting said linear combination from the frequency components $Rp(fj)$ of DMT symbol Rp and applying the resulting difference to the demapping means of said at least one modem (p), to obtain a constellation symbol $(\hat{S}p(fj))$;

calculating the error distance between said constellation symbol $(\hat{S}p(fj))$ and said difference; and

updating the coefficients of said linear combination as a function of said error distance.

8. The FEXT canceling method of claim 7, characterized in that the estimation step provides the constellation symbols $\hat{S}i(fj)$ respectively output by the demappers of the modems i, $i{\neq}p$, as estimates for the symbols $Si(fj)$, $i{\neq}p$.

9. The FEXT canceling method of claim 7, characterized in that the estimation step provides, as estimates for the symbols $Si(fj)$, the frequency components $Ri(fj)$ in a first step and the constellation symbols $\hat{S}i(fj)$, $i{\neq}p$ obtained therefrom in a second step.

10. The FEXT canceling method of claim 7, characterized in that:

the estimation step is carried out for all the LT modems and provides the frequency components (Ri) as estimates for consecutive symbols $(\hat{S}i(fj))$;

the calculation step is carried out for all the LT modems and comprises the calculation at step t of the product $H^{-1}_{t-1}{}^{*}R$ of a matrix H^{-1}_{t-1} with a vector R, R being a vector constituted by all the n DMT symbols Ri, H^{-1}_{t-1} being an estimate at step t-1 of the inverse of the transfer matrix of the plurality of transmission channels;

the error calculating step is carried out for all the LT modems and calculates the error distances between each of the n components of the vector $H^{-1}_{t-1}{}^{*}R$ and the constellation symbols $(\hat{S}i(fj))$ output by the respective demappers of the modems i;

the updating step is carried out for all the LT modems and updates the coefficients of the matrix H^{-1}_{t-1} as a function of said error distance.

11. The FEXT canceling method of claim 7, characterized in that it further comprises:

a parallel to serial conversion of the DMT symbols (Ri) into respective serial streams of frequency components $(Ri(fj))$;
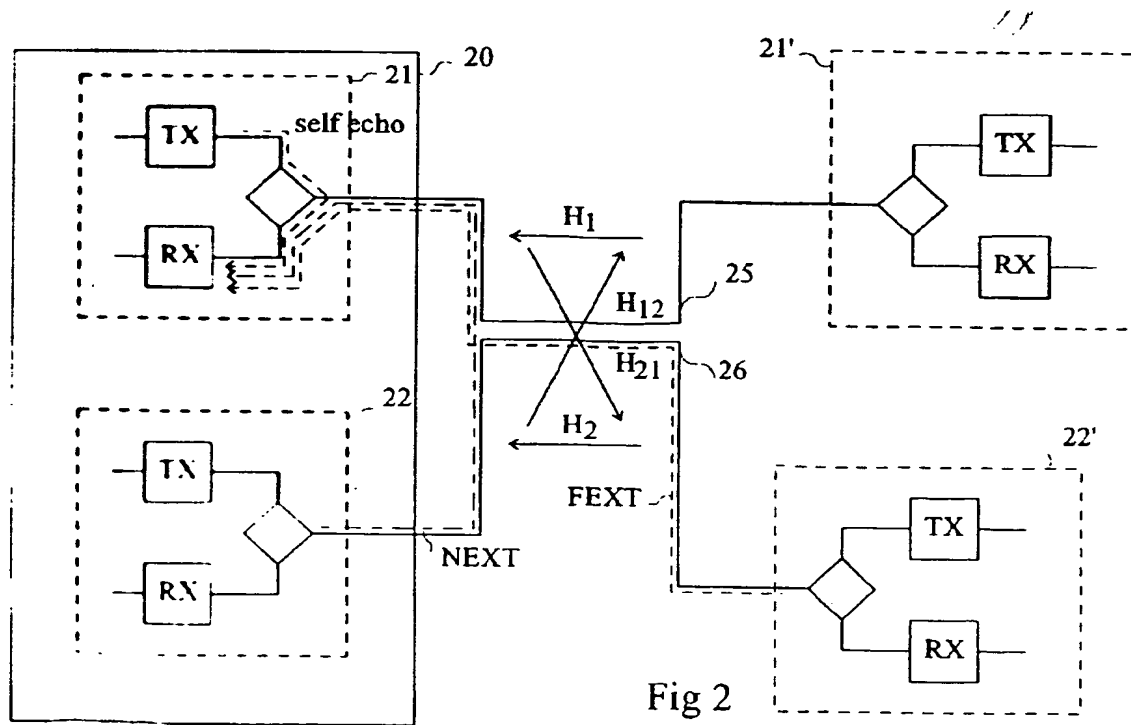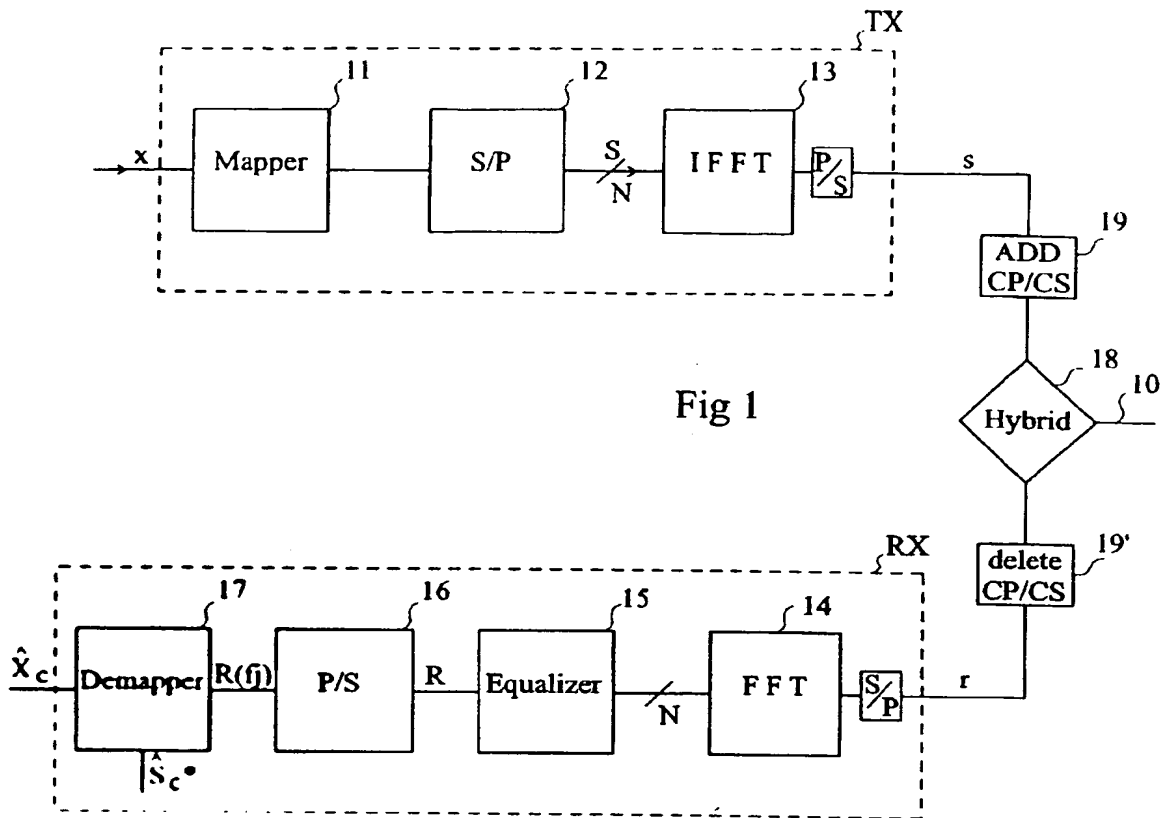wherein:
the estimation step is carried out for all the LT modems and simultaneously provides the frequency components $(Ri(fj))$ as estimates for the symbol $(\hat{S}i(fj))$;
the calculating step is carried out for all the LT modems and sequentially calculates at step t, for each tone j, the product $H^{-1}_{t-1}(fj){}^{*}R(fj)$ of a matrix $H^{-1}_{t-1}(fj)$ with the vector $R(fj)$ constituted by all the frequency components $Ri(fj)$ at the frequency fj, $H^{-1}_{t-1}(fj)$ being an estimate at step t-1 of the inverse of the transfer matrix at the frequency fj of the plurality of transmission channels;
the error calculating step is carried out for all the LT modems and sequentially calculates, for each tone j, the sum of the error distance between each of the n components of the vector $H^{-1}_{t}(fj){}^{*}R(fj)$ and the constellation symbols $\hat{S}i(fj)$ output by the respective demappers of the modems i;
the updating step is carried out for all the LT modems and sequentially updates for each tone j the coefficients of the matrix $H^{-1}_{t-1}(fj)$ as a function of said error distance.
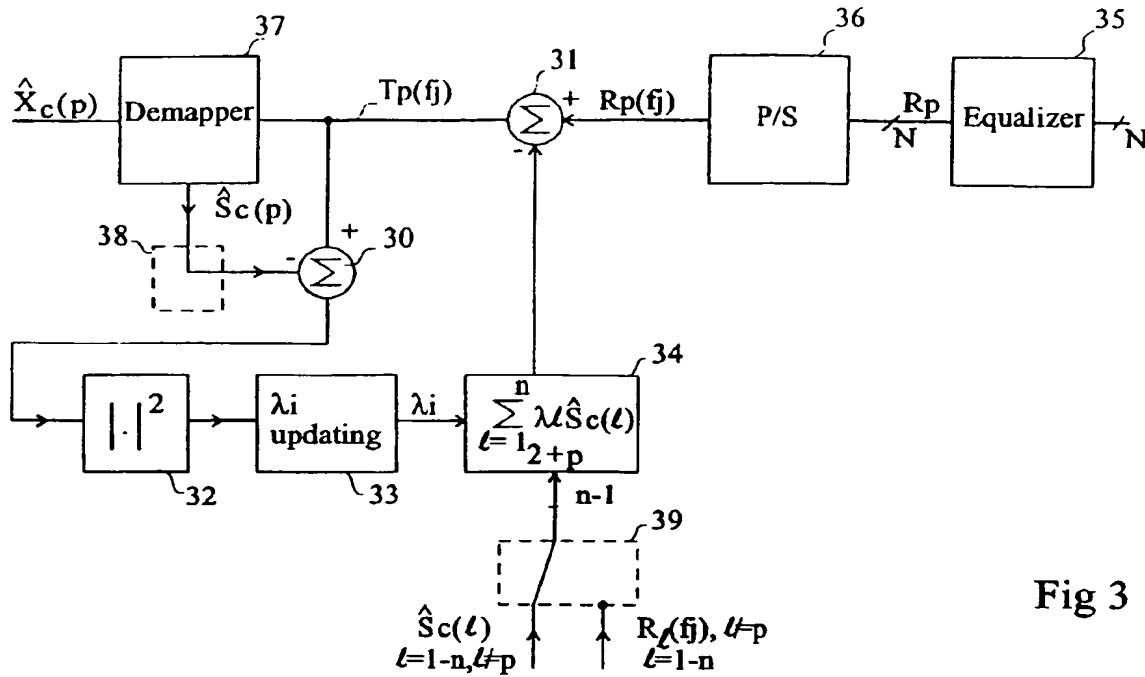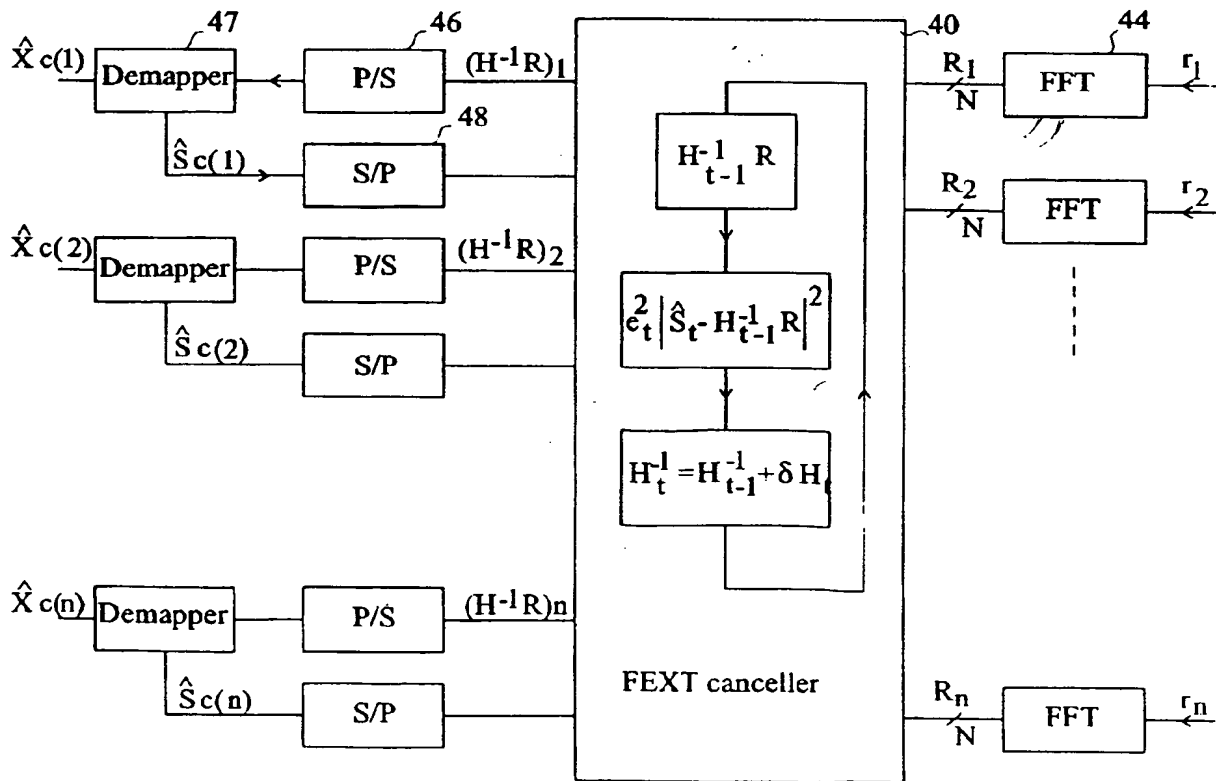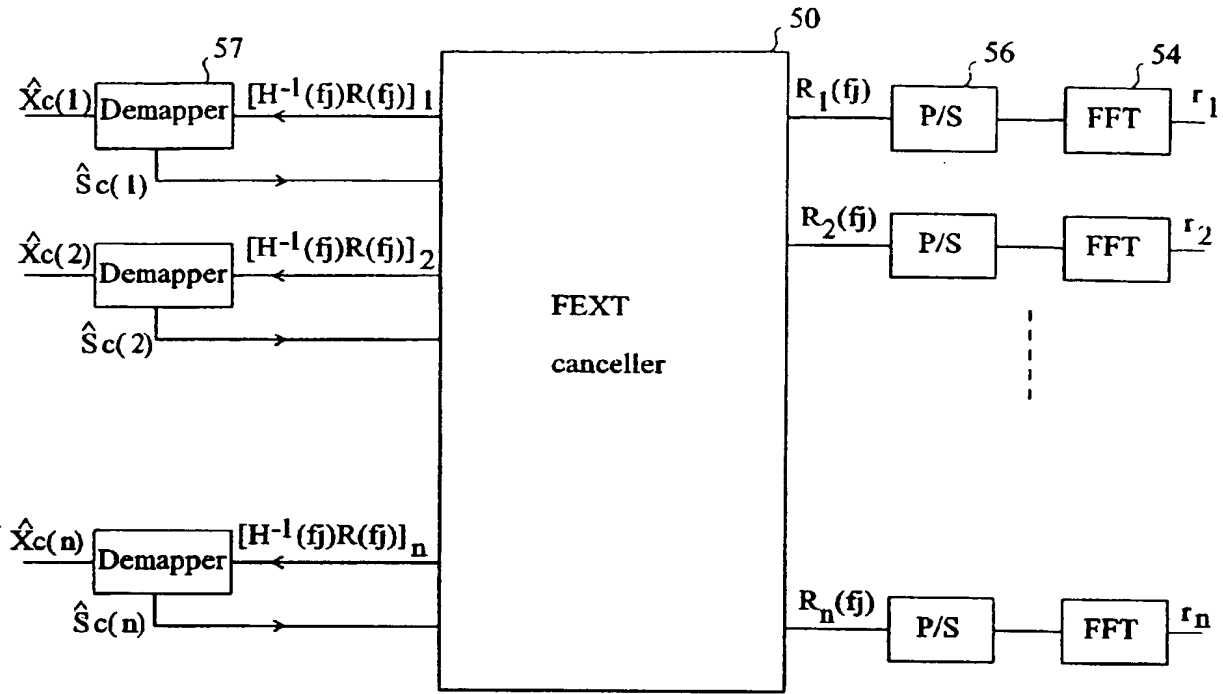
TX

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         ┌─ 11          ┌─ 12              ┌─ 13
    ┌────────────────────────────────────────────────┐
    │   ┌────────┐   ┌────────┐   S    ┌────────┐     │
  x │   │ Mapper │   │  S/P   │  ─/─   │ I F F T│ P/S │  s
──────→│        │───│        │───N────│        │─────│─────
    │   └────────┘   └────────┘        └────────┘     │
    └────────────────────────────────────────────────┘
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ADD
CP/CS ─ 19

Fig 1

Hybrid ─ 18 ─ 10

delete
CP/CS ─ 19'

RX

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    ┌──────────────────────────────────────────────────────────────┐
 X̂c │ ┌─17─────┐R(fj)┌─16───┐ R ┌─15──────┐    ┌─14───┐            │  r
──────│Demapper│────│ P/S  │──│Equalizer│─/──│ F F T│ S/P │───────│────
    │ │        │    │      │  │         │  N  │      │            │
    │ └────────┘    └──────┘  └─────────┘    └──────┘            │
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Fig 2
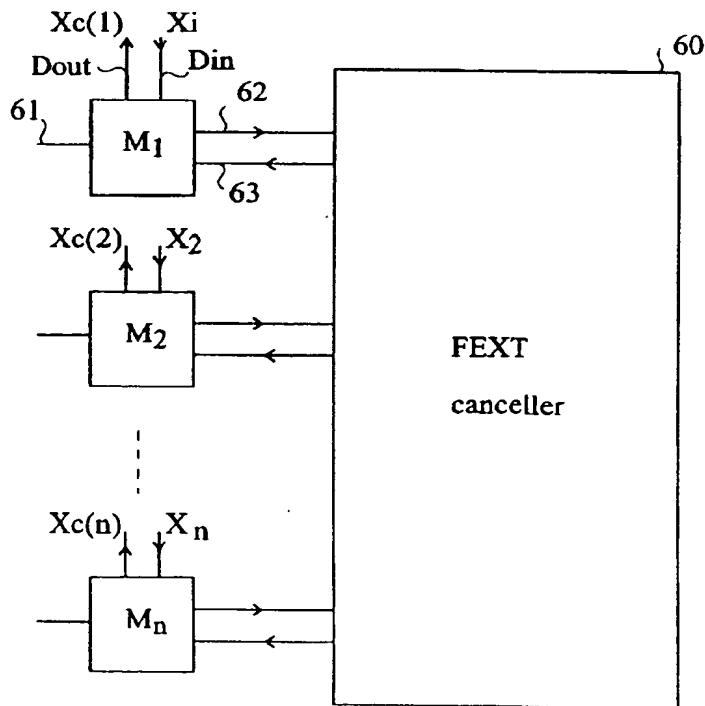
Fig 3

Fig 4

8

Fig 5

Fig 6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 99 41 0174

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A,D	US 5 887 032 A (CIOFFI JOHN M) 23 March 1999 (1999-03-23) * column 3, line 35 - line 48 * * column 3, line 52 - column 4, line 12 *	1-10	H04B3/32
A	US 5 271 037 A (SZECHENYI KALMAN) 14 December 1993 (1993-12-14) * abstract * * column 2, line 53 - line 66; figure 1 *	1-10	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

H04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	9 March 2000	De Iulis, M

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.

EP 99 41 0174

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09-03-2000

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